Chapter

10

10. Electronic Search Patterns

While the mission observer's role seems to be concentrated in visual searches, her contributions in electronic searches are no less important. The observer's understanding of electronic search techniques, and her ability to assist the pilot, can substantially increase both search effectiveness and the timeliness of recovering accident victims.

Electronic searches are most efficient when the equipment, the environment and the terrain are ideal. This includes flat, level terrain, few natural or man-made obstructions and properly functioning equipment. These ideals seldom exist. Therefore, the effectiveness of electronic searches depends heavily on the experience and expertise of the search crews employing them. Through practice, you will understand the difficulties caused by Emergency Locator Transmitter (ELT) signals reflected from obstructions, the adaptability of electronic search methods to overall conditions, and the monitoring of radio equipment to ensure proper operation.

The use of electronic equipment in locating missing aircraft or survivors is an alternative to visual searches. The primary equipment in these type searches is an ELT and an ELT reception device. Once it has been established that an ELT was on board the missing aircraft, a combined track route and ELT search can be launched. The success of this type of search depends on the life of the battery of the ELT, the survivability of the entire ELT unit and whether the unit was activated or not. There is always the possibility ELT equipment may be inoperable due to the effects of the crash. Since an ELT aboard an aircraft does not guarantee that it can be located with an electronic search, both an electronic search and a concentrated general search should be organized at the same time.

OBJECTIVES:

1. Discuss the various types of ELTs. {O & P; 10.1.1}
2. Describe how an ELT can be detected. {O & P; 10.2}
3. Describe how the aircraft DF works in both the Alarm and DF modes. {O & P; 10.3.1}
4. Discuss using the DF during a typical ELT search. Include how the DF should respond during the initial phase (including signal fade), when you are getting close, and when you pass over the beacon. {O & P; 10.3.2}
5. Describe the following ELT search methods: homing, wing null, aural search, and signal search. {O & P; 10.4 - 10.7}
6. Discuss signal reflection and interference. {O & P; 10.9}
7. Describe how to silence an ELT and the legal issues involved. {O & P; 10.10}

10.1 ELTs and SARSAT

Electronic equipment and procedures are used in general searches to focus the search and rescue effort in a specific area, or as an alternative to visual searches when visibility is reduced by weather or other atmospheric conditions. Equipment used in these searches may include a battery-powered emergency locator transmitter (ELT) aboard the incident aircraft, search and rescue satellites, and an ELT receiver aboard the search aircraft.

10.1.1 ELTs

The Federal Aviation Administration (FAA) requires most U.S.-registered aircraft to have operable ELTs installed, which activate automatically when sensing acceleration forces during an accident. An active ELT transmits a continuous radio signal on a specific frequency until it's either deactivated or its battery discharges.

Most general aviation aircraft have ELTs that transmit on 121.5 MHz at 60-100 milliwatts (less power than a small flashlight). They are activated by G-forces or by manual operation of a switch (some aircraft have a remote switch in the cockpit). Space-based monitoring of 121.5 MHz is expected to cease on 1FEB09.

Advanced ELTs that transmit on 406.025 MHz at 25 milliwatts are specifically designed to operate with the Cospas-Sarsat satellite system, and transmit data that contains a unique identifier number that links them to a database containing information on the vessel or aircraft and emergency points of contact. Some advanced 406 MHz beacons also transmit GPS information.

Military Beacons (e.g., URT-33/C) operate on 253 MHz. Personnel ejecting/parachuting from a military aircraft have this beacon; some pilots may be able to communicate via two-way radio on 243 MHz using a PRC-90 or later military survival radio (this radio also has a beacon mode).

Marine Emergency Position Indicating Radio Beacons (EPIRBs) are primarily found on boats and ships. Similar to ELTs, some are automatically activated while others can only be activated manually.

Personal Locator Beacons (PLBs) and Personal Emergency Transmitters (PETs) are currently illegal for general use in the U.S. (but are used by some government agencies). The FCC has proposed changing this rule, allowing 406 MHz PLBs to transmit on frequencies in the 406.0–406.1 MHz band. AFRCC requested that the 406 MHz PLBs rules become effective on or about July 1, 2003, which would allow AFRCC, NOAA and state agencies time to coordinate the transfer of distress alerts to responsible state agencies.

Practice beacons used by CAP transmit on 121.775 MHz. **Avoid calling the practice beacon an "ELT" while communicating on the radio; this can cause confusion.** The term "practice beacon" is very clear to all concerned and should be used on all drills and exercises.

ELTs can (and are) be inadvertently activated. Typical causes are excessively hard landings (Welcome aboard, Ensign!), inadvertent manual activation (e.g., removal/installation), malfunctions, or Monsieur Murphy. Also, non-ELT sources can transmit on 121.5 or 243 MHz; examples are computers, broadcast stations, and even pizza ovens.

Approximately 97% of all received ELT signals turn out to be false alarms. For 121.5 MHz ELTs only 1 in 1000 signals is an actual emergency! False alarms cause problems because SARSAT can only monitor 10 ELT signals at a time and because they block the emergency frequencies (thus blocking a real emergency signal). However, you must always treat an ELT signal as an emergency because you can't know whether the signal is real or false. Additionally, ELT missions keep your skills sharp.

10.1.2 SARSAT/COSPAS

In a cooperative effort among several nations, search and rescue-dedicated satellites (SARSAT and COSPAS) orbit the earth and alert to ELT transmissions. Upon receiving an ELT signal, the SARSAT derives the approximate lat/long coordinates of the ELTs position, and the coordinates are passed through the Air Force Rescue Coordination Center (AFRCC) to the incident commander.

AFRCC will not launch a search until the signal is picked up by at least two satellites. Also, system accuracy in pinpointing the location varies. For a typical 121.5 MHz ELT, accuracy is limited to a 12 nm radius (452 square nm); a 406 MHZ ELT can be narrowed down to a 2 nm radius (12.5 square nm) and one with GPS can be narrowed down to a 0.05 nm radius (0.008 square nm).

Upon receiving SARSAT coordinates, or determining that an ELT was aboard a missing aircraft, the incident commander may launch a combined ELT/visual route search. Search success may depend upon several factors. The fact that an ELT was aboard a missing aircraft does not necessarily guarantee that electronic search procedures will locate it because the unit may have been inoperative or the batteries totally discharged. Also, the crash forces may have been insufficient to activate the ELT or so severe that it was damaged. Incident commanders may attempt to maximize the search effort by conducting an electronic search and a general visual search simultaneously when weather and other circumstances permit.

10.2 Locating the ELT Signal

Before you can use any technique to locate an ELT, you must first be able to pick it up on your radio. The route (track line) pattern (Figure 10-1) or the parallel track (Figure 10-2) search patterns are the most effective at this stage. The aircraft conducting an electronic search will normally begin the search at or near the last known position (LKP) and fly the search pattern at altitudes from 4,000 to 10,000 feet above the terrain if possible. At this altitude, the aircraft can usually intercept the ELT signal, as well as recognize or distinguish the downed aircraft. At the maximum electronic search altitude, which is much higher than 10,000 feet, chances are slim that one can recognize or distinguish a light plane crash site. Maximum track spacing should be used initially to provide a rapid sweep of the probability area. Successive sweeps should have a track spacing one-half the size of the initial spacing. For example, if the track spacing is 60 nautical miles during the initial sweep of the area, then the track spacing for the second sweep of the area should be 30 nautical miles. A third sweep of the area, if needed, should have track spacing of 15 nautical miles. This method of gauging the track spacing applies to both track line (route) and the parallel track. These procedures may be repeated until the missing aircraft or survivors are located, or until it is presumed that the batteries of the ELT have been exhausted.

In mountainous terrain the initial search pattern should be arranged to cross the ridgelines at right angles, if at all possible. The search coverage of the area should be at right angles to the first coverage tracks to compensate for blockage of the ELT signal due to the shape of the terrain.

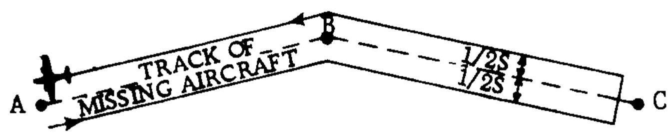

Figure 10-1

Once the searchers are in a position to receive the ELT signal, they may use one of several methods to locate the transmitter and the accident scene. Homing is the simplest and most common method, but it requires special equipment that is not be installed in all search airplanes. The metered search also requires special equipment that may not always be available. The signal-null and aural search methods are used less frequently, but they may be used aboard any airplane equipped with a radio receiver. Each requires only the crew's ability to hear the ELT tone through the search aircraft's radio or intercom.

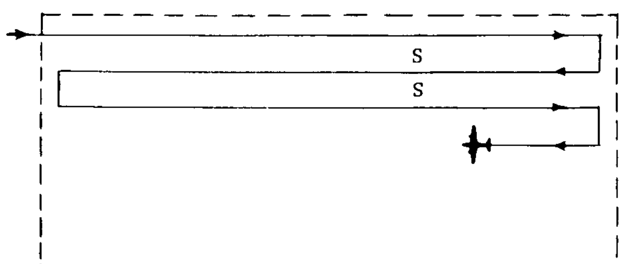

Figure 10-2

10.3 Aircraft Direction Finder (DF)

The L-Tronics LA series Aircraft Direction Finder, the most common DR unit found in CAP aircraft, consists of VHF and UHF receivers, two- or three-element yagi antennas and circuitry. The controls consist of a frequency selector switch, an alarm toggle switch (works like a light switch), and a dual-knob control switch for volume (inner knob) and sensitivity (outer knob). There are two indications: a DF meter and a signal Strength meter (refer to Figure 10-3).

Figure 10-3

The tone-coded squelch circuit, called the Alarm mode, permits continuous, annoyance-free monitoring for Emergency Locator Transmitters (ELTs) and Emergency Position Indicating Radio Beacons (EPIRBs) on 121.5 MHz.

The DF unit is normally connected to the aircraft audio system. This connection allows an audible as well as a visual alarm when an ELT signal is detected in ALARM mode.

The three-whip antenna array provides for dual band operation. The performance of the DF is absolutely dependent on the antenna installation. The whip antennas and the aircraft structure work together to form the directive antenna patterns necessary to the operation of the DF set.

There is considerable interaction between DF and comm antennas. The DF switching may put a strong tone on communications receiver signals from some directions. The DF may have to be turned off or the aircraft heading changed for good comm intelligibility. In particular, the DF receiver may cause interference to communications on 132.3 MHz when operating on 121.5 MHz (126.85 MHz when using 243.0 MHz).

10.3.1 Normal Operations and Checks

The Alarm mode is the normal mode for routine conditions. It enables the pilot to monitor the emergency frequency (121.5 MHz) without dedicating a communications radio to the task. DO NOT USE THIS MODE DURING A DF SEARCH because the DF function is disabled in the Alarm mode.

To select the Alarm mode, place the Alarm toggle switch on (up). Set the SENSitivity so that the needle just comes on-scale and the VOLume to a comfortable level (the ear will detect a weak signal far sooner than the alarm). [Note: The Alarm mode is designed to work with weak signals; if an ELT is transmitting nearby and the unit is set to full sensitivity, the receiver may overload.]

If an ELT activates the Alarm, turn the Alarm toggle switch off (down). This activates the DF function and allows you to track the signal.

The alarm unit automatically rejects false signals. The ELT signal must remain at sufficient strength for 5-20 seconds before the alarm light (flashing red LED) is activated.

<u>Functional Check - No transmitter</u>

This is a quick check that can be made part of a pre-flight routine to assure that a previously checked unit is still working:

1. Select 121.5 MHz on the DF.
2. Turn the Alarm toggle switch off (down).
3. Turn the SENSitivity control (outer knob) fully clockwise to maximum.
4. Turn on power to the radio system.
5. Turn on the DF by advancing the VOLume control (inner knob).
6. A hissing sound should be heard through the audio system and the signal strength needle will be between ¼ and ½ of the way between the center of the scale and the left-hand end. The DF needle will stay roughly centered.
7. Now turn the SENSitivity control counterclockwise toward minimum. This will cause a decrease in sound volume (some sound may still be heard) and a decrease in the strength meter reading.
8. Next, turn the SENSitivity control to maximum. The DF needle should move randomly back and forth one or two needle-widths about the center in response to receiver background noise. *Movement will be slow and may be difficult or impossible to see*.

9. As a final check, turn the Alarm toggle switch to on (up). The Alarm light should flash for 10 to 20 seconds and then stop. The receiver noise should also cut off at the same time. The Alarm is now set and will respond to a steady ELT signal. *[NOTE: This Alarm setting period occurs each time the Alarm function of the DF is turned on. It tests the Alarm circuits and reminds the pilot that the DF receiver is on.]*

<u>Functional Check - with transmitter and the aircraft on the ground</u>

All features of the DF except the Alarm circuit can be checked using a practice beacon.

1. Park the aircraft in the open, away from metal buildings. The transmitter should be at least 50 feet in front of and 15-30 degrees to one side of the aircraft.

   WARNING: Use of high-power transmitters close to the DF antennae can damage the unit. Damage can occur from a 50-watt transmitter if it is within 12 feet of the antennae (3 feet for 5W; 4 1/2 feet for 10W; 15 feet for 80W). The ELT tester should be kept at least 50 feet away from the antennae when using to test for operability of the DF.

2. Select 121.775 MHz on the DF.
3. Rotate the SENSitivity control fully counterclockwise to minimum.
4. Set the VOLume control to about the 12 o'clock position.
5. Set the Alarm toggle switch off (down).
6. Turn on the DF and the transmitter. If necessary, rotate the SENSitivity control clockwise until the signal or the DF buzz is heard.
7. The DF needle should point toward the transmitter. Move the transmitter to the other side of the aircraft and observe the DF needle, which should follow the transmitter. NOTE: On the ground it is normal for the needle to be uncertain about centering with the test transmitter directly fore or aft. The DF is OK if the needle points correctly when the transmitter is on either side of the aircraft.
8. Move the SENSitivity control clockwise. The strength needle will move (slowly) further to the right.

<u>Functional Check - with transmitter and the aircraft in flight</u>

Place the practice beacon as high and clear as possible in open terrain. Fly about three to five miles away at 2000 to 3000 feet AGL. Make several full circles, starting with no more than a 10° bank-angle. The DF needle should crossover only twice during the turn at shallow bank. More than two crossings indicate unsatisfactory operation.

Pilots and observers should note how the DF performs at steeper bank angles for future reference. Note also where wing shadows occur, as indicated by decreases in the strength meter reading and/or audio volume during steep turns. This is a useful verification of DF indications.

Determine the direction to the practice beacon by turning in the direction of DF needle deflection. With the needle centered, follow the DF course inbound and compare it to the visual heading to the target transmitter. The inbound course and the heading to the transmitter should agree to +/- 5° (up to +/- 15° error is quite usable). If desired, you can note the error on a placard near the DF receiver.

Finally, compare the inbound and the outbound courses using the DG (heading indicator). They should differ by 180°.

Course errors of up to 30° are usually due to unsymmetrical installation of the antennas or, on the ground, to nearby reflecting objects (e.g., cars or buildings). Asymmetry usually causes both front and rear courses to be bent toward the same side of the aircraft and usually toward the source of the problem.

Severe errors or one-sided needle indications are usually due to a damaged antenna-to-switchbox cable or to poor grounding at the antenna or a skin joint nearby. Poor skin-joint contact may well indicate structurally significant corrosion and should be investigated by a mechanic.

[NOTE: L-Tronics technical support can be reached at 805-967-4859 or www.ltronics.com]

10.3.2 DF Operations

Verify or select 121.5 on the frequency switch and place the Alarm toggle switch to off (down). **The Alarm mode must not be used during a DF search because the DF function is not operable in the Alarm mode (toggle switch up).** Set the SENSitivity to maximum and the VOLume to a comfortable level.

Climb to an altitude of *at least* 3000 to 4000 feet AGL, if possible. Fly to the area of the reported ELT signal (but remember, an ELT search begins the minute you take off). If the ELT cannot be heard in the expected area, climb to a higher altitude. If this fails to acquire the signal, start a methodical search (e.g., area or expanding square).

Unless the beacon is known to be a 406 MHz EPIRB (which doesn't transmit on 243 MHz) or a military beacon (which uses 243 MHz and may also transmit on 121.5 MHz), switch between 121.5 and 243 MHz at least once each minute until a signal is heard. All civil beacons except 406 MHz EPIRBs and some military beacons transmit on both frequencies. Undamaged ELTs can usually be heard further on 121.5 MHz than they can on 243 MHz; the reverse is often true for damaged ELTs.

<u>Initial Heading</u>

When first heard, the ELT signal will probably be faint and will build slowly in strength over a period of several minutes. Continue flying until a reasonable level of signal is acquired. The DF needle should deflect to one side and the Strength needle should come on-scale. Resist the urge to turn immediately and follow the needle; instead, make a 360° turn at no more than a 30° bank to ensure you get two needle centerings (approximately 180° apart) to verify the heading. When the turn is complete, center the DF needle and fly toward the ELT. Note your heading (write it down) for reference.

If the ELT is heard on both 121.5 and 243.0 MHz, compare the headings. If they differ by more than 45° or if the turn produces multiple crossovers, try a new location or climb to a higher altitude to escape from the reflections.

While flying toward the ELT the DF needle may wander back and forth around center at 10- to 30-second intervals. This is caused by flying through weak reflections and should be ignored. Fly the heading that keeps needle swings about equal in number, left and right.

<u>Signal Fade</u>

Don't become concerned if the signal slowly fades out as you fly towards the ELT. If this happens, continue on your heading for at least six minutes. If you are still headed toward the ELT the signal should slowly build in strength in three or four minutes and be somewhat stronger than before the fade. If the signal does not reappear, return to where the signal was last heard and try a different altitude.

<u>Getting Close</u>

As you get close to the ELT the signal will get stronger, and you will have to periodically adjust the SENSitivity control to keep the signal strength needle centered (*do not* decrease the VOLume control as this could overload the receiver). You also need to do this if the DF needle gets too sensitive. Periodically yaw the aircraft and observe the DF needle respond (left and right).

<u>Passing Over</u>

A "station passage" is often seen as a rapid fluctuation in signal strength and confused DF readings. Yaw the aircraft to see if the course has reversed (needle goes in the direction of the aircraft turn). If the course has reversed, continue on your heading for a few minutes. Then turn and make several confirmation passages from different angles while continuing your visual search.

10.4 Homing Method

Homing is an electronic search method that uses a direction finder to track the ELT signal to its source. Tune the direction finder (DF) to the ELT operating frequency; the pilot will fly the aircraft to the transmitter by keeping the left/right needle centered. ELT's may transmit on either 121.5 MHz VHF, 243.0 MHz UHF, or both frequencies simultaneously. These emergency frequencies are *usually* the ones monitored during a search, but homing procedures can be used on any radio frequency to which *both* a transmitter and DF receiver can be tuned.

In the following scenario, the search objective is an active ELT at a crash site. The first step is to tune the receiver to the ELT frequency and listen for the warbling tone of the ELT signal. Next you have to determine the direction to the ELT. When you fly directly toward a signal, the left/right needle remains centered. However, when you head directly *away* from the signal, the needle also centers. A simple, quick maneuver is used to determine if you are going toward or away from the signal.

Starting with the left/right needle centered, the pilot turns the aircraft in either direction so that the needle moves away from center. If he turns left, and the needle deflects to the right, the ELT is in front. If the pilot turns back to the right to center the needle, and then maintains the needle in the center, you will eventually fly to the ELT.

If, in the verification turn, the pilot turns left and the needle swings to the extreme left, then the ELT is behind you. Continue the left turn until the needle returns to the center. You are now heading toward the ELT, and as long as the pilot maintains the needle in the center, you will fly to the ELT.

Flying toward the ELT, maintaining the needle in the center of the indicator *is* the actual homing process. If the needle starts to drift left of center, steer slightly left to bring the needle back to the center. If it starts to drift right, turn slightly back to the right. Once you have completed the direction-verification turn, you will not need large steering corrections to keep the needle in the center.

When passing over the ELT or transmission source, the left/right needle will indicate a *strong* crossover pattern. The needle will make a distinct left-to-right or right-to-left movement and then return to the center. This crossover movement is *not* a mere fluctuation; the needle swings fully, from one side of the indicator to the other and then returns to the center.

During homing you may encounter situations where the needle *suddenly* drifts to one side then returns to center. If the heading has been steady, and the needle previously centered, such a fluctuation may have been caused by a signal from a second transmitter. Another aircraft nearby can also cause momentary needle fluctuations that you might not hear, but the needle in the DF will react to it.

Signal reflections from objects or high terrain can also cause needle fluctuations at low altitudes in mountainous terrain or near metropolitan areas.

10.5 Wing shadow method (signal null)

The signal null or wing shadow method is based on the assumption that the metal skin of the search aircraft's wing and fuselage will block incoming ELT signals from the receiving antenna during steep-banked turns. The observer can make simple estimates of the magnetic bearing to the transmitter by checking the aircraft heading when the signal is blocked.

Once the search aircraft completes several signal-blocking turns in different sectors of the search area, the observer can establish the approximate location of the ELT by drawing magnetic bearings, or "null vectors," on the sectional chart. The ELT and accident scene will be at or near the intersection of the null vectors.

To use the null method, you must know the location of your receiving antenna. On a low-wing airplane, like the Piper *Cherokee,* the comm antenna is often mounted on the underside of the fuselage, in line with the wings. On a high-wing airplane, like the Cessna 172, the comm antenna is normally mounted on the top of the airplane, again in line with the wings. [Note: You may also use the receiver of your aircraft's DF unit, which is normally mounted on the bottom of the aircraft.]

10.5.1 Procedures

First, verify the receiver is tuned to the proper ELT frequency and that you can hear the warbling tone. Mark your position on the sectional chart, preferably over a small but significant feature. Then the pilot will make a 360° steeply banked turn to allow you to determine the signal's direction. As the airplane turns, the ELT tone will break, or null, at the point when the aircraft wing and skin come between the transmitter and the antenna. For a brief instant you will not hear the tone. The absence of the audible tone is referred to as the *null*.

On low-wing aircraft with the antenna installed on the underside, the wing inside the turn, or the "down" wing of the banking airplane, points toward the ELT when the tone nulls. On high-wing aircraft, with the antenna installed on the top surface, the wing on the outside of the turn, the "up" wing, points toward the ELT when the null is heard.

To estimate the magnetic bearing from the search airplane to the ELT, the observer makes simple calculations. In high-wing airplanes, if you're turning left, add 90° to the aircraft heading when you hear the tone null. If you're turning right, subtract 90° from the heading at the instant you hear the tone null. In low-wing airplanes, when you're turning left, subtract 90° from the aircraft heading, and when making right turns, add 90° to aircraft heading.

You may find it simpler to make these bearing estimates using the face of the Heading Indicator. Imagine an aircraft silhouette on the face of the HI: the silhouette's nose points up toward the twelve o'clock position, and the tail points toward the bottom or six o'clock position. The left wing points left to nine o'clock, and the right wing points to three o'clock. Some heading indicators actually have this silhouette painted on the instrument face, as shown in Figures 10-4 and 10-5. This imaginary plane always mimics whatever the search airplane is really doing.

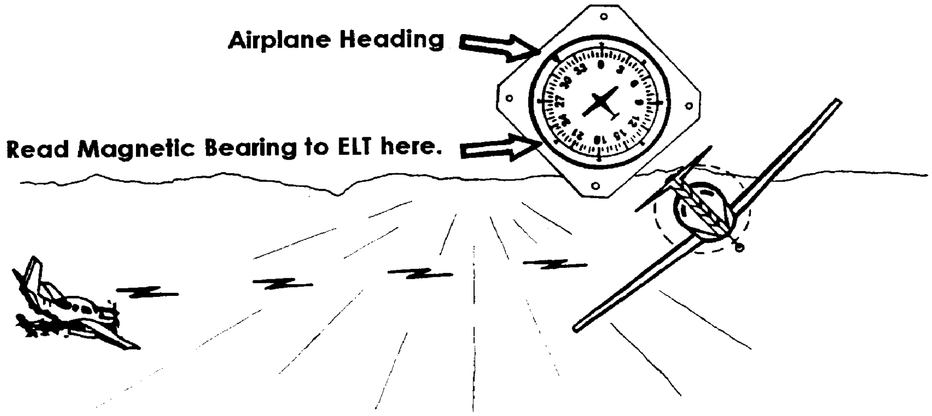

Figure 10-4

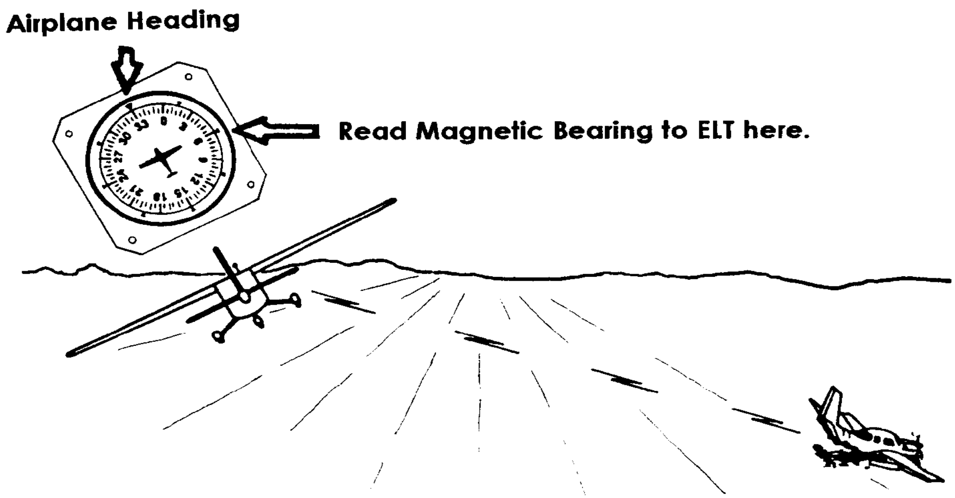

Figure 10-5

Upon hearing the null, the observer should quickly look at the heading indicator. If the search aircraft is a low-wing aircraft, like the *Cherokee,* look for the number adjacent to the imaginary aircraft's low wing, as shown in Figure 10-4. If the search plane is a high-wing, like the Cessna 172, look for the number adjacent to the imaginary plane's high wing, as shown in Figure 10-5. That number is the magnetic bearing from the search aircraft's present position to the ELT transmitter.

Regardless of the method used to determine the ELT's magnetic bearing, the next step is to convert that magnetic bearing to a true bearing by adding or subtracting the published magnetic variation for that area. Then draw a line on your chart from the search aircraft's known position in the direction of the calculated true bearing. You now have one null vector, or line of position, to the ELT. The ELT is somewhere along that line, but it isn't possible to tell exactly where. To narrow the focus, simply repeat the process starting from another known position over a different geographical point. Don't pick your next geographical point near to or along the initial null vector. The accuracy of this technique improves if you select geographic points well away from each other. If the points are well separated, the null vector lines will intersect at a larger angle, and the position will be more accurate.

Figure 10-6 shows an entire null signal search. Notice that several fixes may be taken before deciding the limits for the subsequent visual search. Finally, fly to the area indicated by the null-vector intersection and attempt to pinpoint the ELT.

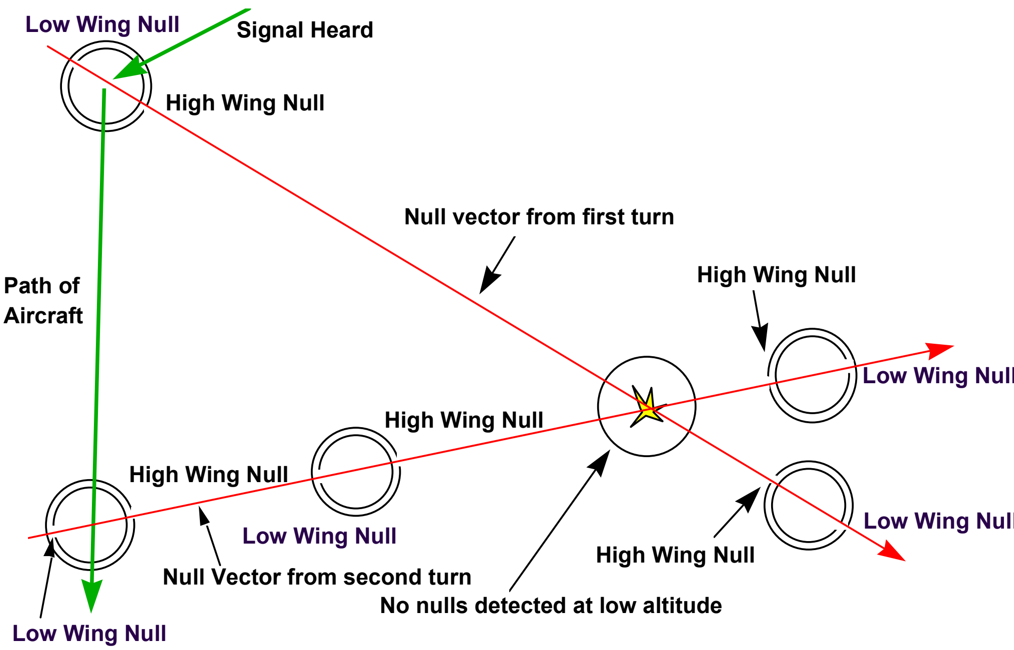

Figure 10-6

Upon reaching the area, the pilot can descend to a lower altitude and execute similar steep turns. If you are very close to the ELT, you can expect to hear no null, due to the higher signal strength near the transmitter and the inability of the wing to block the signal. When an ELT tone is continuous through a full 360° turn, the ELT transmission is very likely in the area beneath the search aircraft. You can then chart the probable location of the missing aircraft or transmitter to within a small area.

If descending to a lower altitude brings the aircraft within 1,000-2,000 feet above the terrain, you should discontinue null procedures. Instead, you should descend to an appropriate lower altitude and begin a visual search.

10.5.2 Special Considerations in Wing Null Searches

Four special considerations must be made prior to and during wing null searches. The most important is crew ability. Maintaining altitude throughout steep turns requires skill and extensive practice. Some aircraft may stall and then spin if over-controlled in poorly executed turns. This can result in a great loss of altitude, structural damage to the airplane during recovery, or collision with the ground. The pilot must be skilled in executing steep-banked turns.

Second is positive knowledge by the search crew of its actual position when the null is heard. By constantly monitoring the search aircraft's position in the turn, you can plot each null vector more precisely.

Third, the search crew must know what to do if the signal is lost during a search. If you lose the signal while trying to pinpoint the ELT's location, you can return to the position and altitude of the last contact with the tone. The observer's chart is a useful record of each position where successful procedures were performed.

Finally, as you approach the suspected ELT location, be more alert for other aircraft. Since a search is likely to include more than just your airplane, you should expect the ELT location to become a point of convergence for all aircraft involved in the search. Once you establish the general location of the downed aircraft, you *must* approach the area with caution. A midair collision can easily result if the entire crew's attention is focused on the accident scene while other aircraft approach the same area.

10.6 Aural (or hearing) search

The aural or hearing search technique is based on an assumption that an ELT's area of apparent equal signal strength is circular. Throughout this procedure the observer *must not* adjust the receiver volume. A constant volume helps assure that "signal heard" and "signal fade" positions will remain consistent. Also, once you begin the procedure, make all turns in the same direction as the first turn if terrain permits. When using this procedure, which does not require a special antenna, the search aircraft is flown in a "boxing in" pattern.

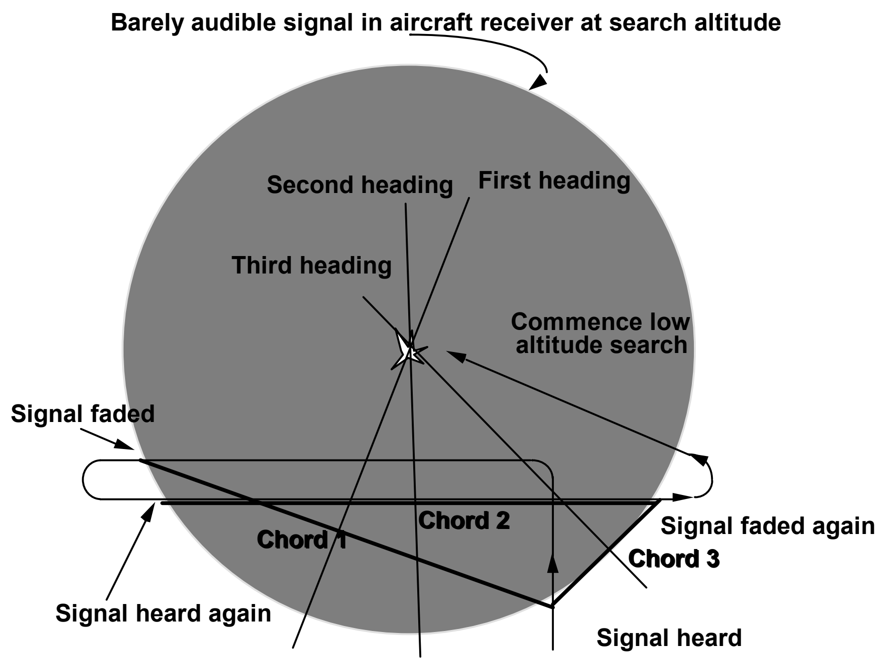

Figure 10-7

The observer begins the aural search by plotting the search plane's position when the ELT tone is first heard. The pilot continues flying in the same direction for a short distance, then turns 90° left or right and proceeds until the tone volume fades. The observer charts the aircraft position where the tone volume fades. The pilot then reverses aircraft direction, and the observer again marks on the map the positions where the signal is heard again and where it fades. If the radio volume has not been adjusted, the "signal fades" and "signal heard" positions should be approximately equidistant from the ELT. To determine the approximate location of the ELT, the observer draws lines to connect each set of “signal heard” and “signal fade” positions.

To establish the approximate position of the ELT unit, the observer draws chord lines between each set of "signal heard" and "signal fade" positions. Then the observer draws perpendicular bisectors on each chord. The bisectors are drawn from the mid-point of each chord toward the center of the search area. The point where the perpendicular bisectors meet, or intersect, is the approximate location of the ELT unit (Figure 10-7 illustrates the connection of the signal heard and signal fade positions with the chord lines, the perpendicular bisectors' converging toward the center of the search area, and the intersection over the probable location of the ELT). After the observer establishes the approximate location where the missing aircraft may be found, the pilot flies to that location and begins a low-altitude visual search pattern. [Note: The perpendicular bisectors rarely intersect directly over the objective. However, a low-altitude visual search of the general area can help compensate for lack of precise location.]

10.7 Metered search

To employ the metered search method, the observer uses a signal strength meter to monitor the ELT signal (Figure 10-8). Circled numbers represent the sequence of events: numbers plotted along the track are hypothetical signal meter readings with higher numbers representing weaker signals and lower numbers representing stronger signals.

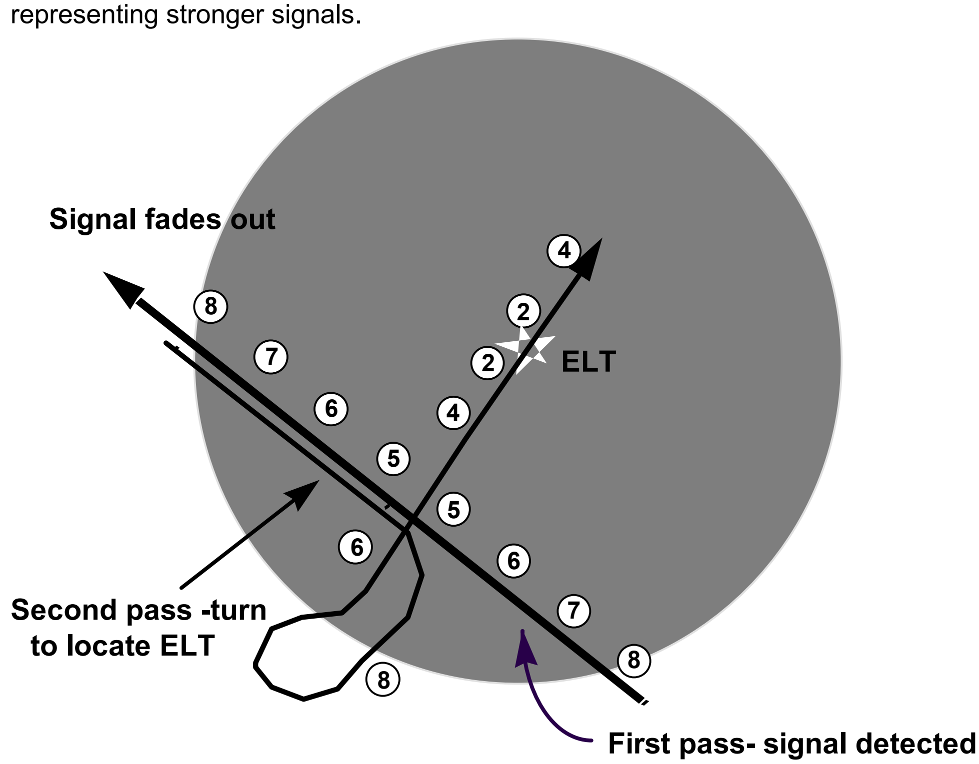

Figure 10-8

Once the aircraft enters the search area, the observer plots two positions of equal meter strength. The observer records the first ELT signal strength (assume the signal strength measures 8.0) and plots the search aircraft's position on the chart. The pilot continues flying the aircraft in the same direction and the signal strength will first increase, then decrease. When the signal strength returns to the previous value (8.0), the observer plots the aircraft's position. The observer now plots the midpoint between these two points, while the pilot reverses direction and flies back toward that midpoint. Upon reaching the midpoint, the pilot makes a 90° turn to the right or left. If signal strength begins to fade, the search aircraft is heading in the wrong direction and the pilot corrects by reversing direction. This last change now carries the search aircraft toward the ELT. The search crew then begins a visual search at an appropriate altitude.

10.8 Night and IFR electronic search

Each of the preceding electronic search methods has certain limitations that affect its usefulness during darkness or in instrument conditions. In this discussion, "instrument meteorological conditions" (IMC) means weather conditions that compel the pilot and crew to operate and navigate the aircraft by referencing onboard instruments and navigational radios.

10.8.1 Night ELT searches

Darkness eliminates your ability to precisely determine your position in reference to the ground, and that impacts the effectiveness of your search. GPS or VOR navigation will enable you fly to the vicinity of the ELT, but you probably won't be able to pinpoint the ELT's position. Exceptions to this are if the ELT is located on an airfield or the occupants of the target aircraft are able to signal you.

Once you've successfully homed to an ELT you can only narrow the target area down to about one square mile. At this point you will have to call in a ground team or land at the nearest airport, arrange for transportation, and find the ELT with hand-held equipment.

10.8.2 IMC ELT searches

It is possible to DF in IMC, but this is dangerous and not to be undertaken lightly. The FAA requires that, for flight in instrument conditions, both pilot and airplane must have special certification. Instrument flight imposes a higher workload on the pilot and demands a higher level of training and proficiency. As discussed earlier, the ability to fly steep-banked turns and other maneuvers without losing altitude is demanding for even the most proficient pilot. Trying to conduct these maneuvers while flying solely by referencing the flight instruments is not wise; the pilot can easily get vertigo and lose control of the aircraft. For these reasons only highly trained and proficient pilots should attempt to DF in IMC, and it is highly recommended that another equally proficient instrument-rated pilot fly in the right seat.

10.9 Signal Reflection and Interference

Radio signals reflect off terrain and manmade objects, and this can be a problem for search and rescue teams. In an electronic search, it is vitally important to know if the equipment is reacting to reflected signals and what you can do to overcome the problem. Although tracking a signal is the best means of locating an ELT, actually isolating the signal can occasionally become a problem. The following scenario illustrates one approach to a signal reflection problem.

After receiving a briefing, the pilot and observer check their aircraft and take off. Upon reaching the designated search area, the observer picks up an ELT signal. Using the DF, the search crew follows the signal for 10 minutes in a northerly direction. The observer later notes that keeping the left/right needle centered requires a 60° turn. This sudden turn causes the observer to conclude the signal is being reflected for two reasons. First, it is highly unlikely that the aircraft wreckage moved, causing a change in direction. Second, if sufficient crosswind was present to cause the change, it should have been noticeable earlier. Since the wreck didn't move, and there is no significant crosswind, the observer concluded that the apparent course problem was caused by reflected signals.

The observer can have the pilot climb to a higher altitude to eliminate or minimize the effects of reflected signals. Reflected signals are usually weaker (lower signal strength) than those coming directly from the transmitter, so climbing can help the stronger direct signals come through. Also, depending on the terrain, a higher altitude may result in more time available for the crew to detect the transmitter. Figure 10-8 shows how climbing to a higher altitude can help overcome the problem of signals blocked by terrain.

NOTE: You can take advantage of the fact that reflected signals are generally weaker by tuning your radios further away from the primary frequency (signal-offset). Assume the ELT is transmitting on 121.5; one radio will be tuned to this frequency and the other will be set to 121.55. You toggle back and forth between the two frequencies as you approach the suspected location until you hear a signal on 121.55. As you home in on the target make 121.55 the primary and set 121.6 on the other radio and repeat the process (you may even work up to 121.7). As you get further away from the initial frequency the area where the signal will break through the squelch becomes smaller and smaller (you can even turn up the squelch to get further isolation). This method also works well from the ground.

The specific pattern used during an electronic search over mountainous or hilly terrain can help compensate for blocked signals and reflections. You should alternate flying patterns parallel to valleys or ridges, and flying the patterns at perpendicular angles. The following example (Figure 10-9) demonstrates this technique.

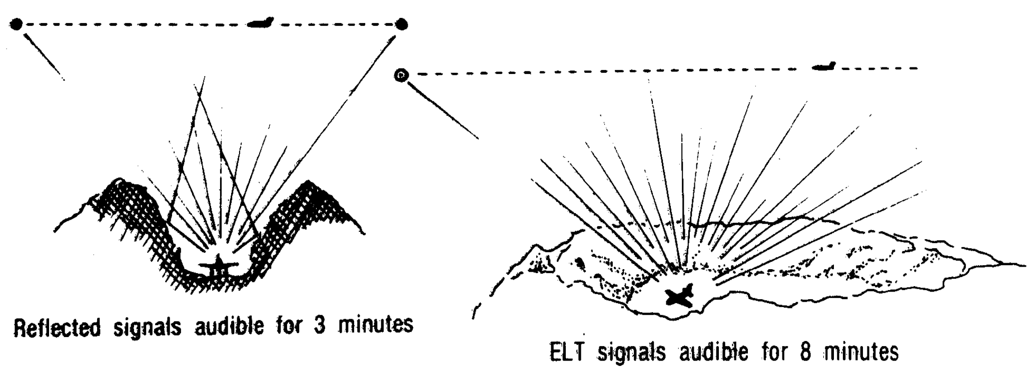

Figure 10-9

The crew receives the briefing and flies to its assigned area. A range of mountains extending north to south divides the rectangular-shaped area. The search crew elects to fly the initial pattern over the area east to west, and then returns west to east. After making 5 uneventful passes over the mountains 10,000 feet above the terrain, the observer hears the ELT on the sixth pass. On subsequent passes the observer hears the signal for three minutes during each pass and plots each area where the signal was audible. To further define the ELT position, the observer requests the pilot fly a course perpendicular to the previous headings. This new course takes the aircraft parallel to the mountain range. On the third pass near the mountains, the observer hears the ELT again, this time for eight minutes. After another pass over the area to verify the eight-minute reception, the observer plots a small area on the map as a likely location of the ELT. The observer concludes that terrain is a major factor in causing the signal to be audible for short periods of time. The missing aircraft has possibly crashed in a ravine or narrow canyon that permits transmission of the ELT signals to a limited area above the crash site.

Descent to a lower altitude helps confirm the observer's speculation. The missing aircraft has crashed in a long, narrow ravine running parallel to the north-south mountain range. The mountain walls around the aircraft significantly limit transmission of the signals in an east-west direction, so the observer is only able to hear the signal for three minutes while searching in an east-to-west or west-to-east direction. When the aircraft track is parallel to the mountain range, the observer hears the signal for eight minutes. When the crew flies along the length of the ravine where the plane crashed, they are able to maintain signal contact for a longer time.

When faced with strange circumstances like the two examples described above, try to visualize the situation and search for a logical explanation. Consider every factor that could cause the problem, including equipment reliability, terrain, other sources of interference like the electrical fields of high-tension power transmission lines, and the direction finding procedures themselves. If one method of electronic search doesn't yield the results you expect, try another method. Don’t become so involved with one method that you can't switch to a more suitable method if the situation demands.

NOTE: If a signal is *only* received on 243 MHz, it *may* be a malfunctioning antenna (e.g., an FAA tower). If you DF to the location (particularly on or near an airport) and you keep ending up at an antenna, investigate. Find out who owns the antenna and its purpose. Inform the IC and let the controlling agency troubleshoot the problem.

Electronic searches are normally only as effective as the crews employing them. They work best when the equipment, environment, and terrain are ideal. Unfortunately, such ideal conditions seldom exist. Crews must practice search methods to better understand difficulties caused by various conditions. This will help them be prepared to deal with less than ideal conditions. Whenever you are faced with strange circumstances, you should seek the most logical explanation. In looking at the problem, always consider every factor that could possibly cause the situation. Consider the equipment reliability, the terrain and the DF procedures. If one method of electronic search doesn't yield the type of results you expect, try another method. Don't become so involved in one method that you can't adopt a more suitable method if the situation demands it.

NOTE: The newest CAP Direction Finder, the *Becker SAR-DF 517*, is in limited use and so is not covered here. Information on this unit can be found in Attachment 2 and at www.beckerusa.com.

10.10 Silencing an ELT

If you don't have a ground crew and you have determined the ELT signal is coming from (or very near) an airfield, you will have to land and find the offending aircraft. You can use a hand-held DF unit (Little L-Per or Tracker) and/or a hand-held radio to locate the aircraft.

Sometimes you locate the hanger and find it is full of aircraft. Two methods are very useful in narrowing down the search: the signal-offset method was discussed in section 10.9; another way is to use a hand-held radio without its antenna. Hold the radio by one of the suspect aircraft's ELT antenna and turn the volume down until you can just hear the signal, then move to the next suspect aircraft and hold the radio next to its antenna. If the signal is stronger you probably have it; if it is weaker or cannot be heard it's probably the other aircraft. You may also incorporate portions of the signal-offset method with this method. [*Warning*: Do not key the radio's transmitter while the antenna is removed!]

Don't ignore the obvious: some aircraft have remote indicating lights (usually red) that flash when the ELT has activated; also look for obvious signs of disturbance near an ELT.

Once you have determined which aircraft the signal is coming from, you have to find the (physical) ELT. Most are located in the rear of the aircraft; also look for remote switches. The following gives some general locations:

- Single-engine Cessna: right side of the upper baggage area immediately aft of the baggage door.
- Multi-engine Cessna: left side of the fuselage just forward of the horizontal stabilizer. Accessed through a small push-plate on the side of the fuselage.
- Single- and multi-engine Piper: in the aft fuselage. Accessed through a small access plate on the right side of the fuselage (need a screwdriver).
- Single- and multi-engine Bonanza: in the aft fuselage. Accessed through a small access plate on the right side of the fuselage (need a screwdriver).
- Large piston twins (e.g., King Air) or small jets: if installed its probably in the rear section. No visible antenna. May have a small round push-plate that gives you access to the switch with your finger.

The preferred method of silencing a transmitting ELT is to have the owner (or a person designated by the owner) turn it off and disconnect the battery; second best is just turning it off. Some owners will take the switch to OFF and then back to ARMED; monitor the emergency frequency for several minutes afterwards to ensure the ELT doesn't resume alarming.

If you cannot find the owner (or designee), you may have to install an aluminum foil 'tent' to limit the ELT signal range. Refer to Figure 10-10.

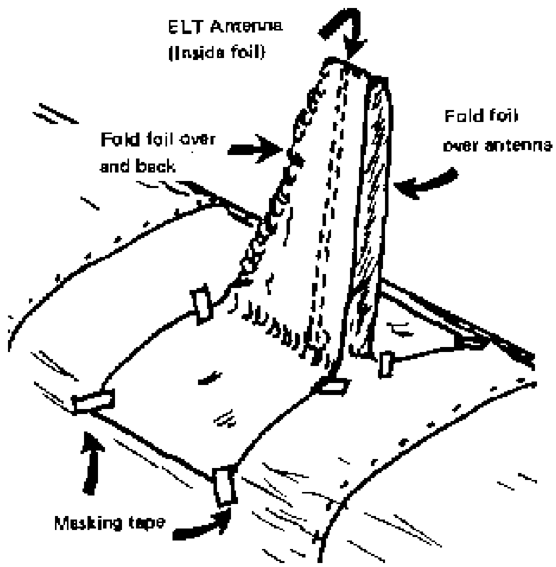

Figure 10-10

Take a piece of foil about one foot wide by about five feet long. Place the tip of the ELT antenna in the center of the foil and fold the foil down on both sides of the antenna. Let the ends lay flat against the fuselage; the flaps *must* extend at least 18" beyond the antenna. Fold the two sides of the 'tent' together to completely enclose the antenna and *securely* tape the foil to the fuselage (use a tape that won't damage the paint, such as masking tape).

Whatever you do, *do not leave an ELT/EPRIB in the alarm state unless ordered to do so by the IC/AFRCC*. You will have to consult your IC, AFRCC, and/or law enforcement to silence the ELT if the above methods are not practical.

Last but not least, ensure the aircraft owner is notified that the ELT was disabled. If you can't obtain a phone number, you can put a note on the aircraft (not a window) stating that the ELT has been disabled. Make your own notes and carry some in the aircraft.

10.10.1 Legal Issues

Per CAPR 60-3 Chapter 1, CAP members will not enter private property and should not do anything that could cause harm or damage to the distress beacon or aircraft/boat. If entry is required the owner/operator or local law enforcement officials will make it.

A transmitting ELT is under the legal authority of the FCC, and federal law requires that it be deactivated ASAP. However, CAP members *do not have the authority to trespass onto private property*, either to gain access to the aircraft or to enter the aircraft to gain access to the ELT. You must gain permission from the owner before you enter a private hanger or an aircraft. In some cases, especially at an airport, FBO personnel have permission to enter aircraft on the premises and can assist you.

While entry upon private property may be justified if such an act is for the purpose of saving life, every effort should be made to obtain the controlling agency's and/or the property owner's consent. If you need entry onto private property in order to search for an ELT, law enforcement authorities such as local police, the county sheriff's office or game wardens may be contacted for assistance.

Normally, local law enforcement officials (don't forget Game Wardens) are happy to assist you. If they are not familiar with CAP and your responsibilities, a simple explanation often suffices. If this doesn't work, try calling AFRCC and have them explain the situation.

That said, when searching under the tasking of the AFRCC, CAP forces are "assisting" the FCC and no one else. If a local law enforcement officer prevents a CAP ground team from going on to an accident scene to deactivate the ELT, the deputy is in the wrong. Now, that does not mean you just shove your way past the deputy. You call your IC, who calls the AFRCC, who calls the Sheriff at home at 3:00 a.m. and explains that the Sheriff really doesn't want to get crosswise with the FCC. The Sheriff is usually only too happy to call the deputy and allow the ground team to enter the scene to deactivate the ELT.

NOTE: A *crashed* aircraft is under the authority of the National Transportation Safety Board (NTSB) *and no one else*. Federal law permits the NTSB to request assistance from federal, state and local agencies (including CAP) to secure a crash site.

Each state is the master of its own territory and appoints a chief SAR officer. Under a state-federal MOU, the AFRCC coordinates all inland SAR efforts. Note that 'coordinate' is not the same as 'command.' While AFRCC has legal authority to tell you to search someplace, the state SAR officer has legal authority to tell you NOT to.

The most important aspect appears to be the manner in which the CAP personnel approach the matter. The local civil authorities are in charge. In some states, the chief SAR officer may be the governor; in some it may be the state Adjutant General of the National Guard. If the AFRCC tasks you to search, you go search and offer assistance to the civil authorities when the opportunity presents itself. If they tell you go home, then phone AFRCC and close the mission. If that happens, try to go up the chain of command to make contact and get the USAF to find out what the problem is, and how to solve it.

The FCC may issue warning letters, violation notices and fines, if appropriate in cases involving non-distress activations. However, if you run across a hoax or activation through gross negligence it should be reported to the nearest FCC field office.

Although not your responsibility, owners may ask you whether or not they can fly with a deactivated or inoperative ELT; the rules are found in FAR 91.207. An aircraft with an inoperable ELT can be ferried from a place where repairs or replacements cannot be made to a place where they can be made [91.207(3)(2)]. An aircraft whose ELT has been temporarily removed for repair can be flown if aircraft records contain an entry concerning the removal, a placard is placed in view of the pilot showing "ELT not installed," and the aircraft is not operated more than 90 days after the ELT was removed [91.207(f)(10)].

10.10.2 AFRCC information

You need to keep a log of the ELT search in order to provide certain information to AFRCC. This information will be given to the Incident Commander, and is required before AFRCC will close out the mission.

1. Date and time (Zulu) you left on the sortie.

2. Date and time the ELT was first heard.
3. Time in the search area and time enroute (hours and minutes; Hobbs).
4. Area(s) searched.
5. Actual location of the ELT, including latitude and longitude.
6. Date and time the ELT was located and silenced.
7. ELT model, manufacturer, serial number and battery expiration date.
8. Position in which you left the ELT switch: On, Off, or Armed.
9. Other (not required): 'N' or vessel number, make and model, owner information, and how the ELT was actuated.